capacitive sensing device that is divided into several independent and spatially distinct sensing points that are positioned throughout the plane of the touch screen. Each sensing point is capable of generating a signal at the same time. The touch screen also includes a sensing circuit that acquires data from the sensing device and that supplies the acquired data to the processor.

The invention relates, in another embodiment, to a touch screen method. The method includes driving a plurality of sensing points. The method also includes reading the outputs from all the sensing lines connected to the sensing points. The method further includes producing and analyzing an image of the touch screen plane at one moment in time in order to determine where objects are touching the touch screen. The method additionally includes comparing the current image to a past image in order to determine a change at the objects touching the touch screen.

The invention relates, in another embodiment, to a digital signal processing method. The method includes receiving raw data. The raw data includes values for each transparent capacitive sensing node of a touch screen. The method also includes filtering the raw data. The method further includes generating gradient data. The method additionally includes calculating the boundaries for touch regions base on the gradient data. Moreover, the method includes calculating the coordinates for each touch region.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

FIGS. **1**A and **1**B show a user holding conventional touch screens.

FIG. **2** is a perspective view of a display arrangement, in accordance with one embodiment of the present invention.

FIG. **3** shows an image of the touch screen plane at a particular point in time, in accordance with one embodiment of the present invention.

FIG. **4** is a multipoint touch method, in accordance with one embodiment of the present invention.

FIG. **5** is a block diagram of a computer system, in accordance with one embodiment of the present invention.

FIG. **6** is a partial top view of a transparent multiple point touch screen, in accordance with one embodiment of the present invention.

FIG. **7** is a partial top view of a transparent multi point touch screen, in accordance with one embodiment of the present invention.

FIG. **8** is a front elevation view, in cross section of a display arrangement, in accordance with one embodiment of the present invention.

FIG. **9** is a top view of a transparent multipoint touch screen, in accordance with another embodiment of the present invention.

FIG. **10** is a partial front elevation view, in cross section of a display arrangement, in accordance with one embodiment of the present invention.

FIGS. **11**A and **11**B are partial top view diagrams of a driving layer and a sensing layer, in accordance with one embodiment.

FIG. **12** is a simplified diagram of a mutual capacitance circuit, in accordance with one embodiment of the present invention.

FIG. **13** is a diagram of a charge amplifier, in accordance with one embodiment of the present invention.

FIG. **14** is a block diagram of a capacitive sensing circuit, in accordance with one embodiment of the present invention.

FIG. **15** is a flow diagram, in accordance with one embodiment of the present invention.

FIG. **16** is a flow diagram of a digital signal processing method, in accordance with one embodiment of the present invention.

FIGS. **17**A-E show touch data at several steps, in accordance with one embodiment of the present invention

FIG. **18** is a side elevation view of an electronic device, in accordance with one embodiments of the present invention.

FIG. **19** is a side elevation view of an electronic device, in accordance with one embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the invention are discussed below with reference to FIGS. **2**-**19**. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

FIG. **2** is a perspective view of a display arrangement **30**, in accordance with one embodiment of the present invention. The display arrangement **30** includes a display **34** and a transparent touch screen **36** positioned in front of the display **34**. The display **34** is configured to display a graphical user interface (GUI) including perhaps a pointer or cursor as well as other information to the user. The transparent touch screen **36**, on the other hand, is an input device that is sensitive to a user's touch, allowing a user to interact with the graphical user interface on the display **34**. By way of example, the touch screen **36** may allow a user to move an input pointer or make selections on the graphical user interface by simply pointing at the GUI on the display **34**.

In general, touch screens **36** recognize a touch event on the surface **38** of the touch screen **36** and thereafter output this information to a host device. The host device may for example correspond to a computer such as a desktop, laptop, handheld or tablet computer. The host device interprets the touch event and thereafter performs an action based on the touch event. Conventionally, touch screens have only been capable of recognizing a single touch event even when the touch screen is touched at multiple points at the same time (e.g., averaging, masking, etc.). Unlike conventional touch screens, however, the touch screen **36** shown herein is configured to recognize multiple touch events that occur at different locations on the touch sensitive surface **38** of the touch screen **36** at the same time. That is, the touch screen **36** allows for multiple contact points T**1**-T**4** to be tracked simultaneously, i.e., if four objects are touching the touch screen, then the touch screen tracks all four objects. As shown, the touch screen **36** generates separate tracking signals S**1**-S**4** for each touch point T**1**-T**4** that occurs on the surface of the touch screen **36** at the same time. The number of recognizable touches may be about 15.15 touch points allows for all 10 fingers, two palms and 3 others.

The multiple touch events can be used separately or together to perform singular or multiple actions in the host device. When used separately, a first touch event may be used to perform a first action while a second touch event may be used to perform a second action that is different than the first action. The actions may for example include moving an object such as a cursor or pointer, scrolling or panning, adjusting control settings, opening a file or document, viewing a menu, making a selection, executing instructions, operating a peripheral device connected to the host device etc. When used together, first and second touch events may be used for performing one particular action. The particular action may for